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A phenological investigation of various invertebrates in forest and woodland areas in the south-west of Western Australia

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Abstract

Invertebrates were collected in pitfall traps at 3 localities in the south-west of Western Australia: namely Perth (Reabold Hill), Dwellingup and Manjimup. The pitfall traps (diameter 1·8 cm) were spaced 3 m apart in a 6 x 6 grid at each locality. Between March 1976 and February 1977 collections were made once a month from traps exposed for a week. The groups reported on are: Araneida, Acarina, Scorpionida, Pseudoscorpionida, Phalangida, Diplopoda, Chilopoda, Isopoda, Annelida and Gastropoda.

The differences in species richness and abundance between sites are discussed in terms of soil type, fire history and climatic pattern. Species richness of decomposers and predators is lowest at the most recently burnt site (Manjimup) suggesting that there is a period of decreased species richness of at least 3 years following fire. Decomposer abundance, and presumably rate of decomposition, is higher in the wetter months at Perth and Dwellingup although abundance is more closely associated with the warmer months at Manjimup. Predators are active throughout the year although, at Dwellingup and Manjimup, there is a decrease in activity associated with cool moist conditions.

Introduction

Compared to the numerous phenological (seasonal-succession) studies on plant communities (see Lieth 1974), those on invertebrate communities are few. Although such studies have been performed on individual invertebrate species, e.g. cocoa capsids (Gibbs et al. 1968) and on taxonomic groups (e.g. tropical butterflies; Owen and Chanter 1972), the works of Gillon and Gillon (1967) and Gibbs and Leston (1970) on West African savanna and rainforests respectively, are two of the few phenological studies on invertebrate communities.

The results of studies on the continuing biological interactions of ground-dwelling invertebrates of forests and woodlands may ultimately be of value for several reasons; they may (1) lead to a more satisfactory understanding of seasonal influences than solely by using meteorological variables (as pointed out by Gibbs and Leston 1970), (2) reveal the relative importance of various faunal groups in biological systems such as litter decomposition (Springett 1976a, b), and (3) provide a framework of ecological information on which to base forest-management decisions such as suitable seeding or burning times.

During the current studies in the south-west of Western Australia, a great diversity of forms has been encountered. The present paper is confined to the phenology of the arachnids and other non-hexapod invertebrates that were collected from March 1976 to February 1977 inclusive. An attempt is made to define the seasonal succession of the various species at 3 sites having differing climatic regimes. The data on insects will be presented in subsequent papers.

The specimens were collected as a result of a pitfall trapping programme that had been devised to investigate the ants in jarrah forests. The pitfall traps primarily sample the epigaeic fauna, the soil fauna not being efficiently sampled by this method. Southwood (1966) has reviewed the literature and assessed the value of sampling by pitfall trapping and concluded that although unsuitable for obtaining estimates of abundance, this technique may be used to study daily and seasonal activity and also the dispersion of a species in a particular type of vegetation. Greenslade and Greenslade (1971) investigated the performance of pitfall traps containing an alcohol/glycerol preservative and found that whereas the traps did not attract or repel ants, they selectively trapped certain other invertebrates. In the present paper, owing to the likelihood of selective trapping and because of the low numbers of some species collected, the data are considered to be of more value for discussing the seasonal trends than the relative abundance at each site. The overall diversity of invertebrates at each site is also considered.

The study sites

Features of the study sites are summarized in Table 1. The sites are located in a woodland at Perth (Reabold Hill), and in forests at Dwellingup and Manjimup. The trees in these areas are mainly jarrah (*Eucalyptus*

Table 1

Comparison of sites.

Site	Perth (Reabold Hill)	Dwellingup (Curara block)	Manjimup (Dingup block)
Latitude and longitude	31°57′S, 115°47′E	32°52′S, 116°13′E	34°19′S, 116°11′E
Trees present	Jarrah, Tuart, Marri	Jarrah, Marri	Jarri, Marri, Karri
Tree canopy cover at site of grid	59%	70%	87%
Ground cover	70%	24%	32%
Leaf litter	Moderate	Moderate	Moderate
Dead wood	Sparse	Dense	Dense
Time since last burn before survey	*ca* 5 years	*ca* 8 years	*ca* 3 years
Soil and bedrock	Calcareous sands overlying aeolianite (Spearwood dune system)	Residual laterite with gravelly sands overlying ironstone	Grey podsol on Precambrian metamorphic rocks
Comments	Site totally colonised by veldt grass resulting in low density of native plants	Non-commercial trees thinned out since 1970	

marginata); but the Perth site includes tuart (*E. gomphocephala*), whereas karri (*E. diversicolor*) is sparsely distributed throughout the Manjimup site, and all the areas contain marri (*E. calophylla*).

The Perth site is degraded woodland, having been logged; it is colonized by the exotic veldt grass (*Ehrharta calycina*). The other two sites are Forests Department land of high-quality timber. Unmerchantable jarrah and other species of tree have been felled at Dwellingup as part of an experiment to investigate the effects of reduced competition with prospective timber trees. The fire at the Perth site, unlike that at the other sites, was accidental.

Site data on tree canopy and percentage ground cover were obtained by densiometer and metre quadrats respectively. A visual assessment was also made of the amounts of litter and deadwood on the ground, and of the soil type. The figure for the number of years between the last burn and the start of the survey was obtained from City of Perth records for Reabold Hill, and the Forests Department for the two southern sites.

Climatic data

The monthly rainfall totals, monthly maximum and minimum temperatures, and mean monthly relative humidities recorded at the three sites during the study are shown (Figs. 1 and 2).

Relative humidity records are for 0900 hours at Perth and Dwellingup, and 0800 hours at Manjimup. Although the consistently higher humidities observed at Manjimup were undoubtedly influenced by the lower temperatures at the time of recording, there are some Manjimup readings available for 0900 hours and they suggest that the humidity is generally higher here than at the other 2 localities.

Collecting procedure

The pitfall traps consisted of Pyrex test tubes sunk vertically at ground level within PVC sleeves (Majer 1978). They were positioned 3 m apart in a 6 x 6 grid in a typical part of the general environment at each of the three sites. Each of the test tubes (length 15 cm, internal diameter 1·8 cm) contained a 3 mL mixture of alcohol/glycerol (70/30 v/v). The grid of PVC sleeves was retained in the ground to minimise the disturbance to soil and litter during the replacement of tubes. In order to avoid the effects of "digging-in" (Greenslade 1973), trapping was not started until a week after the initial placement of traps.

Every 4 weeks, the tubes were collected after having been left uncorked in their sleeves in the field for 7 days. They were replaced by a set of tubes which were left corked until the start of the next 7-day collecting period.

The collections were hand sorted and identified in the laboratory using a stereo microscope. Specimens have been lodged in the Western Australian Museum, and representatives sent to specialists.

Results

The number of specimens of each species collected during each trapping week over the study period is shown in Table 2. Because sampling was performed at 4-week intervals, the sampling dates did not necessarily coincide with the calendar months. Therefore for clarity, the data have been centralised under each calendar month in Table 2. In the few instances where 2 samples were obtained in a month the mean number is given.

The specimens collected belong to 2 broad feeding categories, predators and decomposers. The feeding type to which each species belongs is indicated in Table 2. The total number of species in the 2 feeding groups trapped per month at each site, and the total number of species and individuals for the year are shown in Table 3.

It should be noted that both in numbers of species and individuals, the predators exceed decomposers at all sites. This is due to lower vagility rather than to lower densities of the decomposers. Also, overall species richness at the Manjimup site is less than that at the other 2 sites. No inter-site comparisons will be made on the total numbers of individuals at each site because the results were probably influenced by variations in trapping efficiency.

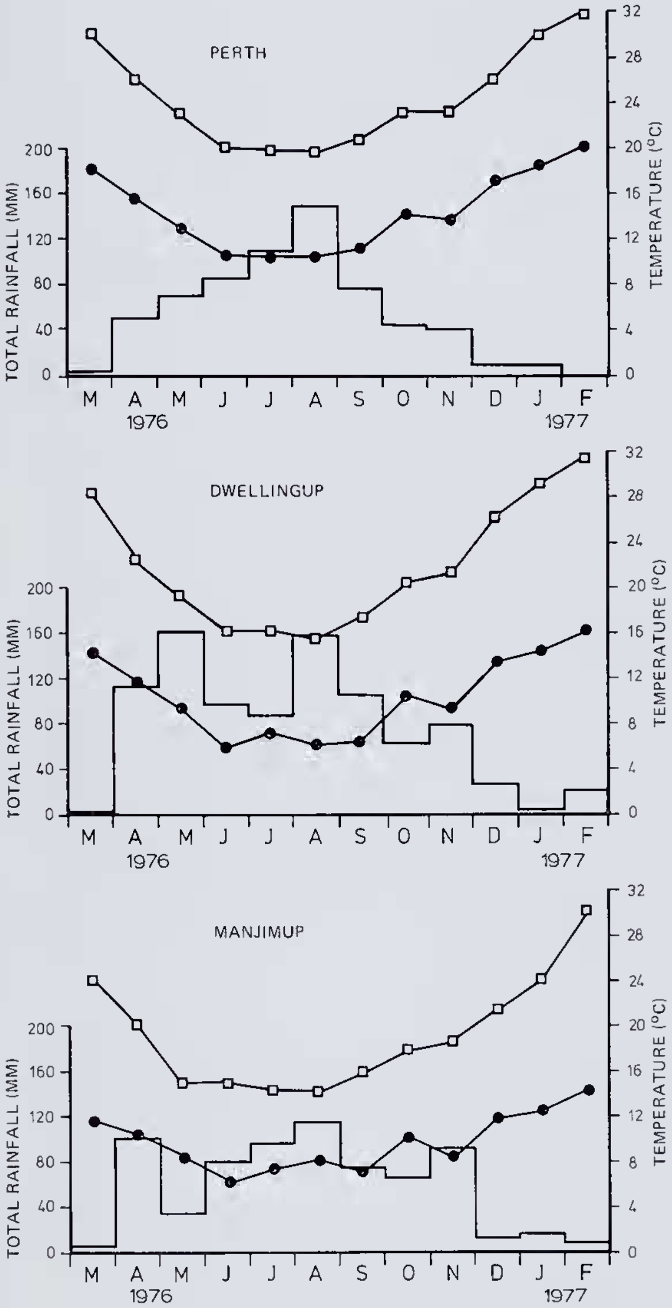

Figure 1.—The monthly rainfall and mean monthly temperatures (maximum □——□; and minimum ●——●) at Perth, Dwellingup and Manjimup from March 1976 to February 1977.

At Perth, the activity period of decomposers, as measured by species richness, occurred in late winter and spring. At Dwellingup the period of decomposer occurrence in the traps started earlier (May) and extended into early summer (December). At Manjimup, the seasonal trend was reversed and the activity period was from November to April (Table 3).

Predators were present in all months at each site although reductions in predator occurrence in traps were noted at Dwellingup in May and June, and at Manjimup in June and July. No obvious trends were noticeable at Perth (Table 3).

The number of decomposer and predator species trapped per month may be regarded as an index of decomposer and predator activity. The numbers trapped per month were compared (using Spearman's Rank Correlation) with the climatic data for the corresponding month and the previous month. The correlation coefficients and significance values are shown in Table 4. The correlations that are significant (at the 0·05 and 0·01 probability levels) are discussed below.

The species richness of decomposers is positively correlated with the relative humidity and rainfall of the previous month at Perth, and with the rainfall of the previous month at Dwellingup. Unlike those at the two northern sites, the decomposers at Manjimup are positively correlated with the temperature of the corresponding and also of the previous month; they are negatively correlated with the relative humidity of the corresponding month.

Compared to decomposers, the activity of predators is less tied to climatic conditions. At Dwellingup, rainfall of the previous month is negatively correlated with species richness of predators. At Manjimup, relative humidity of the corresponding month is negatively correlated with species richness of predators, whereas temperature of the previous month is positively correlated with it. There are no significant correlations at Perth between the climatic data and the species richness of predators.

Discussion

There are few studies of Western Australian forest-floor invertebrates. Most synecological investigations have regarded the effects of prescribed burning on the soil and litter fauna. In his pioneer work, McNamara (1955) studied the invertebrates of the soil and humus in jarrah forests and compared burnt and unburnt compartments and also areas suffering from crown deterioration. He concluded that the microfauna contained more individuals and taxa in places with accumulated organic matter. Springett (1976a) working on soil and litter fauna in burnt and unburnt forests of jarrah at Dwellingup and karri at Pemberton found that species

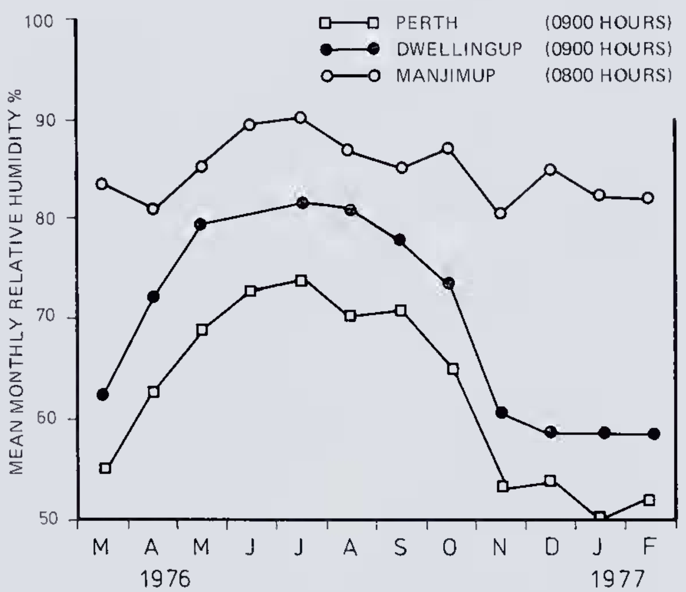

Figure 2.—The mean monthly percentage relative humidities at Perth, Dwellingup and Manjimup from March 1976 to February 1977.

Table 2

The number of individuals of each species of non-hexapod invertebrate collected per month in pitfall traps at three sites in the south-west of Western Australia from March 1976 to February 1977.

		1976 M	A	M	J	J	A	S	O	N	D	1977 J	F
ARACHNIDA: ARANEIDA													
(Mygalomorphae)													
Ctenizidae													
Missulena (pred.)†	M*	0	0	1	0	0	0	0	0	0	0	0	0
Dipluridae													
Chenistonia tepperi (pred.	P	0	0	0	0	0	0	0	0	0	1	0	0
	D	0	0	0	0	0	0	0	0	0	1	0	0
(Araneomorphae)													
Oonopidae (pred.)	P	0	0	0	0	0	0	0	0	3	0	1	0
	D	0	1	0	0	0	1	0	0	0	0	0	0
Salticidae (pred.)	P	1	1	0	0	0	2	0	1	1	0	0	6
	D	0	2	0	0	0	0	0	1	3	2	1	1
	M	0	0	0	0	0	1	0	0	2	0	0	0
Clubionidae (a) (pred.)	D	1	6	0	0	0	2	1	0	0	2	0	0
Clubionidae (b) (pred.)	M	0	0	0	0	0	0	2	0	0	0	0	0
Clubionidae (c) (pred.)	D	0	1	0	0	0	1	1	0	2	0	0	0
Gnaphosidae (pred.)	P	5	1	1	15	0	0	1	0	5	7	3	6
	D	4	5	0	0	5	1	1	13	7	3	8	0
	M	1	1	1	2	0	0	0	1	5	5	0	0
Ctenidae													
Elassoctenus harpax (pred.)	P	5	1	7	2	0	0	2	1	1	0	0	0
	D	0	4	0	0	1	0	2	0	0	0	0	0
Ctenidae (b) (pred.)	P	0	0	0	1	0	0	0	6	0	0	0	0
Linyphiidae (a) (pred.)	D	0	0	0	4	2	0	1	0	0	0	0	0
	M	0	0	0	0	0	0	1	0	0	0	0	0
Linyphiidae (b) (pred.)	D	0	0	0	8	11	0	2	0	0	0	0	0
	M	0	0	0	1	0	0	0	0	0	0	0	0
Zodariidae													
Storena (pred.)	P	0	0	0	0	0	0	0	0	2	3	1	0
	D	5	1	0	0	0	0	1	6	1	2	6	2
	M	2	0	0	0	0	4	0	2	5	0	0	0
Zodariidae (b) (pred)	P	0	0	0	0	0	0	1	1	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	1	0
Lycosidae													
Artoria (a) (pred.)	P	0	0	0	21	27	83	123	0	8	3	2	0
	D	0	0	0	2	0	0	2	1	1	2	1	0
	M	0	0	0	0	0	0	5	0	0	0	0	0
Artoria (b) (pred.)	D	0	0	0	0	3	1	0	0	0	0	0	0
	M	0	0	1	0	8	1	0	0	0	0	0	0
Artoria (c) (pred.)	P	0	0	0	0	0	1	0	0	0	0	0	0
ARACHNIDA: ACARINA													
Rhodacaridae (pred.)	P	2	0	113	0	0	0	22	0	0	0	0	0
	D	17	1	0	0	3	0	0	0	1	0	0	0
Trombidiidae (pred.)	P	190	12	5	2	2	0	0	2	13	17	79	156
	D	28	1	0	0	3	1	2	25	87	46	31	18
	M	30	1	0	0	0	0	0	0	0	24	67	139
Anystidae (pred.)	P	1	0	0	0	0	0	0	0	0	3	32	4
	D	24	7	1	0	0	0	0	1	12	24	46	15
ARACHNIDA: SCORPIONIDA													
Bothriuridae													
Cercophonius squama (pred.)	P	0	0	1	1	0	2	0	0	0	0	0	0
	M	1	1	1	0	0	0	0	0	0	0	2	2
Buthidae													
Lychas marmoreus (pred.)	P	0	0	0	0	0	0	0	0	0	0	0	1
	D	0	0	0	0	0	0	0	1	0	0	1	0

		1976										1977	
		M	A	M	J	J	A	S	O	N	D	J	F
ARACHNIDA: PSEUDOSCORPIONIDA													
Chthoniidae													
Austrochthonius australis (pred.)	P	0	0	0	1	0	0	0	0	1	0	0	0
	D	0	0	0	0	1	0	0	1	0	0	0	0
ARACHNIDA: PHALANGIDA													
Trianenonychidae													
Nunciella (pred.)	P	0	0	0	4	7	0	0	0	0	0	0	0
	D	4	3	6	3	0	0	3	6	2	1	0	0
	M	0	5	1	0	0	3	0	2	5	4	2	0
DIPLOPODA													
Polyzoniidae													
Rhinotus (dec.)	D	0	0	0	0	0	0	1	0	0	0	0	0
Siphonotus flavomarginatus (dec.)	P	0	0	0	0	3	0	0	0	0	0	0	0
Paradoxosomatidae													
Antichiropus fossulifrons (dec.)	P	0	2	0	0	0	0	3	5	1	0	0	0
	D	0	0	0	0	1	0	0	0	1	2	0	0
Antichiropus (b) (dec).	M	0	0	0	0	0	0	0	0	1	0	0	0
Antichiropus (c) (dec.)	P	0	0	0	0	0	0	0	3	0	0	0	0
CHILOPODA													
Henicopidae													
Henicops (pred.)	P	0	0	0	2	9	2	2	8	0	0	0	0
	D	0	0	0	0	0	0	0	1	1	1	0	0
Scolopendridae													
Cormocephalus (pred.)	P	0	0	0	0	1	0	0	0	0	0	2	3
	D	0	0	0	0	0	1	0	0	0	0	0	3
Geophilidae (pred.)	M	0	0	0	0	0	0	0	0	0	0	0	1
CRUSTACEA: ISOPODA													
Armadillididae (a) (dec.)	P	0	0	0	0	0	0	1	1	0	0	0	0
	D	0	0	0	0	0	0	2	0	1	1	0	0
	M	3	2	0	0	0	0	0	0	2	14	5	0
Armadillididae (b) (dec.)	P	0	0	0	0	0	2	0	1	0	0	0	0
Oniscidae													
Laevophiloscia (a) (dec.)	P	0	0	0	0	0	0	0	1	0	0	0	0
	D	0	0	1	1	0	0	0	0	1	0	0	0
	M	3	2	0	1	0	2	0	0	2	0	0	0
Laevophiloscia (b) (dec.)	D	0	0	0	0	0	0	0	1	1	0	0	0
Laevophiloscia (c) (dec.)	P	0	0	0	0	0	0	0	1	0	0	0	0
	M	2	0	0	0	0	0	0	0	4	0	2	21
Oniscidae (b) (dec.)	D	0	0	0	0	1	0	0	0	0	0	0	0
Oniscidae (c) (dec.)	D	0	0	0	1	0	0	0	0	0	0	0	0
ANNELIDA													
Megascolecidae (dec.)	D	0	0	0	0	1	0	0	0	0	0	0	0
MOLLUSCA: GASTROPODA													
Bulimulidae													
Bothriembryon (dec.)	P	0	0	0	0	2	0	0	0	0	0	0	0

* P — Perth; D — Dwellingup; M — Manjimup; † (pred.) — predator; (dec.) — decomposer.

Table 3

The numbers of species trapped per month (March 1976 to February 1977) and the total species and individuals of decomposers and predators trapped at each of the three sites.

Site	M	A	M	J	J	A	S	O	N	D	J	F	Total species trapped at site	Total individuals trapped at site
							Decomposers							
Perth	0	1	0	0	2	1	2	6	1	0	0	0	8	26
Dwellingup	0	0	1	2	3	0	3	2	3	2	0	0	8	19
Manjimup	3	1	0	0	0	0	0	0	3	1	3	2	3	65
							Predators							
Perth	6	4	5	8	5	5	6	6	8	6	7	6	19	1065
Dwellingup	7	11	2	4	8	6	10	9	10	10	8	5	21	582
Manjimup	4	4	4	2	1	4	3	3	4	3	3	3	13	341

diversity and density are reduced following burning of the native forests. Bornemissza (1969) studied the soil and litter invertebrates in a burnt area of native bushland at Kings Park, Perth, and concluded that most soil- and litter-dwelling invertebrates had regained normal population levels after 2 or 3 years.

Springett (1971, 1976b) compared the soil and litter fauna of *Pinus pinaster* plantations and native woodlands at Gnangara, north of Perth. This study suggested a lower species diversity of soil microarthropods in pine plantations than in native vegetation, but abundance levels were similar. Associated decomposition experiments suggested that the microfauna in pine plantations was impoverished and unable to decompose litter as fast as in native vegetation.

The only other reported synecological studies on forest-floor invertebrates in Western Australia are the analysis of arthropod succession in decomposing carrion and the effects of this on soil fauna (Bornemissza 1957), the investigation of epigaeic invertebrate succession in replanted bauxite mines at Jarrahdale (Scott 1974), and the attempt to relate karri forest invertebrate abundance to that of the insectivorous marsupial, the mardo, *Antechinus flavipes* (Hindmarsh and Majer 1977). With the exception of certain taxa in Springett's work, these studies have sorted most of the invertebrates only to ordinal level. The present study provides data on individual species and for the first time provides information on the phenology of certain invertebrates.

In accordance with differences in geological, vegetational, drainage and other characteristics, the soil is different in the various areas. Unlike the other two sites, the Perth site (Reabold Hill) has tuart (Table 1) which is characteristically found on the soils of the Spearwood dune system of Pleistocene age. The residual laterite of the Dwellingup site overlies ironstone, whereas the Manjimup soils are grey podsol on Precambrian metamorphic rocks. The calcium content is high at the Perth site, unlike at the other two sites and at Gnangara, near Perth. The Gnangara soil is quartz sand, not limestone; its calcium content is very low, and its pine-litter layer is highly acidic. The calcium content affects creatures such as snails (e.g. *Bothriembryon*) which are dependent upon this element for their shells. It is interesting to note that snails of this genus were collected in pitfall traps only at Perth. Similarly, the varying preferences of other creatures for calcium and other features of the soil and litter layers no doubt contribute towards determining which species occur in each area.

Table 4

Spearman's rank correlation coefficients and significance values for trapped species (decomposers and predators) and climate of corresponding month and previous month at three sites ($n = 12$).

Site	Average Temperature†		Relative Humidity		Rainfall	
	Corresponding month	Previous month	Corresponding month	Previous month	Corresponding month	Previous month
			Decomposers			
Perth	-0·29	-0·34	0·46	0·75**	0·48	0·75**
Dwellingup	-0·51	0·11	0·33	0·48	0·17	0·56
Manjimup ..	0·77**	0·74**	-0·74**	0·48	-0·38	0·43
			Predators			
Perth	0·17	0·06	-0·34	-0·25	-0·37	-0·16
Dwellingup	0·17	-0·36	-0·28	-0·27	-0·09	-0·70*
Manjimup	0·20	0·57*	-0·62*	-0·12	0·001	0·31

* $P < 0·05$ ** $P < 0·01$

† The average of the monthly maximum and minimum temperatures was used.

Our observations have indicated that the numbers of species in our traps are a true reflection of the total numbers of species present at each of these sites, so the lower diversity of decomposers and predators at the Manjimup site requires an explanation. The number of taxa collected at a particular site does not necessarily reflect that of the general locality. Springett (1976a) found that the mesofauna in jarrah and the more southern karri forests is represented by similar numbers of species, and the studies by one of us (Majer; unpublished) on forest ants indicate that there are similar species richness values for these three localities. A striking difference between the Manjimup site and the other two sites is that it had been burnt only 3 years before the study commenced (Table 1). This falls well within Springett's (1976a) period of post-fire species diversity reduction—suggesting that fire could be the reason for the observed differences in species richness.

It is expected that the amount of decomposition or predation is proportional to the number of species of decomposers or predators respectively that are active (and hence trapped) at any given time. The data on decomposers are therefore interesting in that they point to variations in the rate of decomposition throughout the year and between sites. Before discussing this, the differences in climates at the 3 sites should briefly be considered (Figs. 1 and 2). There is no consistent trend in rainfall as one passes south through the study sites, although Dwellingup has the highest rainfall in most months. There is, however, a reduction in mean maximum and minimum temperatures from north to south and, with this, an increase in relative humidity. There are probably moister conditions on the forest floor at the 2 more southerly sites.

Decomposers at Perth and Dwellingup have a winter-spring activity. They are correlated with the previous month's rainfall and relative humidity at Perth, and with the previous month's rainfall at Dwellingup (Table 4). There is a longer period of decomposer activity at Dwellingup than at Perth (Table 3), indicating that Dwellingup's higher rainfall and humidity (Figs. 1 and 2) result in the moist conditions that favour the processes of decomposition lasting longer. This conclusion is in agreement with the findings by Hatch (1955) that there was a very slow rate of decomposition of jarrah leaf litter at Dwellingup during the summer and a rapid initial loss of weight of litter during March to August inclusive. The Perth data tie in with Springett's (1976b) observation that there was a lower loss of weight of litter under pines at Gnangara during mid-summer. Although no data are available, we postulate that decomposition continues for a longer period at Dwellingup than at Perth.

At Manjimup, the absence of non-hexapod decomposers in traps run between May and October suggests that the winter period is here in some way less suitable for decomposition. Four possible reasons for this different surface activity of decomposers are: (1) that the low winter temperatures are unfavourable; (2) that the extremely wet soil and litter in winter may be unsuitable; (3) that the rains in the warmer season at Manjimup make these periods the most suitable for decomposition; (4) that it is an artifact of the sampling programme. It would be interesting to place out litter bags or calico strips, as Springett did, in order to evaluate the decomposition period at Manjimup.

With regard to the predators, no clear seasonal trends can be defined for the winter decreases in activity at Dwellingup and Manjimup. These are associated with high rainfall of the previous month at Dwellingup, and high humidity of the corresponding month at Manjimup. It may simply be that conditions are too cool for predator activity during this winter period; this view is supported by correlation of predator numbers with the high temperatures of the previous month at Manjimup (Table 4). Certainly when one looks at the numbers of the more abundant predators, such as spiders (and also ants), marked periods of increased activity are noticeable in the spring-summer-autumn period. It may well be that the bulked data used here obscure the fact that a succession of predators is active thoughout the year.

To summarise, this study has suggested: (1) that there is a period of decrease in species richness for at least 3 years after fire; (2) that decomposer abundance, and presumably decomposition, is higher in the wetter months (except at Manjimup where decomposers are associated with warmer conditions); and (3) that predators are active throughout the year although there is a decrease of activity (at least at Dwellingup and Manjimup) associated with cool, moist conditions.

It would be interesting to know what the relative impact of autumn and spring controlled burns at Perth and Dwellingup will be on predators and decomposers. Probably, an autumn burn would remove the litter layer on which decomposers feed in the months immediately following the burn, and a spring burn would allow a period of litter recovery which would give decomposer organisms a food-base for the following wet period (winter). Our data suggest that different sequences of biological events are operating at the southern locality, Manjimup, and therefore the effects of fire might be different there.

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References

Bornemissza, G. F. (1957).—An analysis of arthropod succession in carrion and the effects of its decomposition on the soil fauna. *Aust. J. Zool.* 5: 1-12.

Bornemissza, G. F. (1969).—The reinvasion of burnt woodland areas by insects and mites. Abstracts of papers presented at seminar on effects of forest fire. *Proc. Ecol. Soc. Aust.*, 4:138.

Gibbs, D. G. and Leston, D. (1970).—Insect phenology in a forest cocoa-farm locality in West Africa. *J. Appl. Ecol.*, 7: 519-548.

Gibbs, D. G., Pickett, A. D. and Leston, D. (1968).—Seasonal population changes in cocoa capsids (Hemiptera, Miridae) in Ghana. *Bull. Ent. Res.*, 58: 279-293.

Gillon, Y. and Gillon, D. (1967).—Recherches ecologiques dans la savane de Lamto (Cote d'Ivoire): cycle annuel des effectifs et des biomasses d'arthropods de la strate herbacee. *Terre Vie.* no. 3: 262-277.

Greenslade, P. J. M. (1973).—Sampling ants with pitfall traps: digging-in effects. *Insectes Soc.*, 20: 343-353.

Greenslade, P. and Greenslade, P. J. M. (1971).—The use of baits and preservatives in pitfall traps. *J. Aust. Ent. Soc.*, 10: 253-260.

Hatch, A. B. (1955).—The influence of plant litter on the jarrah forest soils of the Dwellingup Region—Western Australia. *Leafl. Commonw. For. Timb. Bur., Canberra* no. 70.

Hindmarsh, R. and Majer, J. D. (1977).—Food requirements of mardo (*Antechinus flavipes* (Waterhouse)) and the effect of fire on mardo abundance. *Forests Department of Western Australia. Research Paper* no. 31.

Lieth, H. [Ed.] (1976).—*Phenology and seasonal modelling*. New York: Springer-Verlag.

Majer, J. D. (1978).—An improved pitfall trap for sampling ants and other epigaeic invertebrates. *J. Aust. Ent. Soc.*, 17: 261-262.

McNamara, P. J. (1955).—A preliminary investigation of the fauna of humus layers in the jarrah forest of Western Australia. *Leafl. Commonw. For. Timb. Bur., Canberra* no. 71.

Owen, D. F. and Chanter, D. O. (1972).—Species diversity and seasonal abundance in *Charaxes* butterflies (Nymphalidae). *J. Ent.* (A), 46: 135-143.

Scott, J. K. (1974).—The regeneration of bauxite mining sites. Unpublished Honours Thesis, University of Western Australia.

Southwood, T. R. E. (1966).—*Ecological methods*. London: Methuen.

Springett, J. A. (1971).—The effects of fire on litter decomposition and on the soil fauna in a *Pinus pinaster* plantation. *Proceedings of the Fourth Colloquium of the Zoology Committee of the International Society of Soil Science*, 529-535.

Springett, J. A. (1976a).—The effect of prescribed burning on the soil fauna and on litter decomposition in Western Australian forests. *Aust J. Ecol.*, 1: 77-82.

Springett, J. A. (1976b).—The effect of planting *Pinus pinaster* Ait. on populations of soil mircroarthropods and on litter decomposition at Gnangara, Western Australia. *Aust. J. Ecol.*, 1: 83-87.